

Argonne Nuclear Data Program

□ Nuclear Data **Compilations & Evaluations**

- ✓ nuclear structure compilations and evaluations - **ENSDF & XUNDL**
- ✓ evaluation of atomic masses and nuclear properties - **AME & NuBase**
- ✓ decay data evaluations in support of IAEA-led projects & other horizontal evaluations (nuclear isomers, medical isotopes, nuclear moments, etc.)

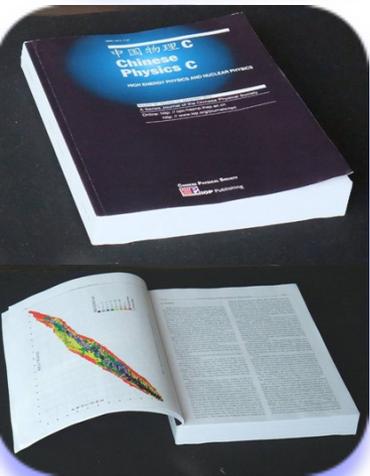
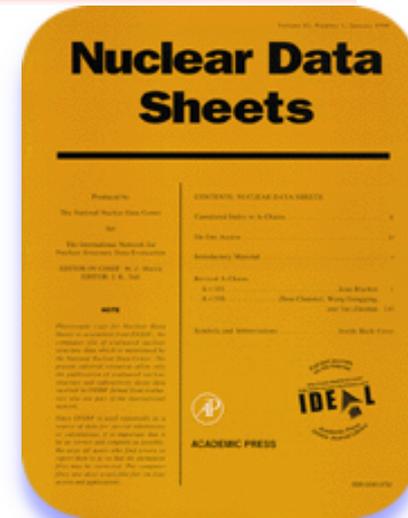
□ Complementary ND **Research** Activities

- ✓ intersections between basic and applied nuclear physics & astrophysics - via collaborative agreements with a little or no cost to USNDP
- ✓ contributions to DOE/NP FOA's - 2 funded at the FY17 call

Evaluations & Compilations - FY2018

ENSDF

- ❑ **A=188** was completed and published in NDS
- ❑ **A=177** was completed and submitted to NNDC for a review & subsequent publication
- ❑ started working on **A=205** - ENSDF priority list
- ❑ review of **A=100** is nearly completed



XUNDL

- ❑ compiled what we were asked to do - 15 papers (51 datasets)
- ❑ continued RIKEN collaboration with Yuichi Ichikawa - declined involvement in ENSDF evaluations

AME & NUBASE

- ❑ continued compilation & evaluation activities

IAEA-NDS collaborations

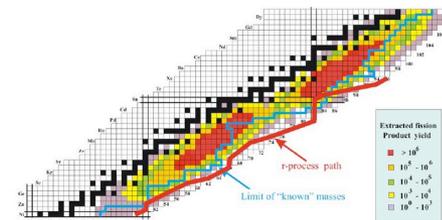
- ❑ CRP on Medical Isotopes; TM on TAGS; consultation(s) on LiveChart; TM on ENSDF codes (benchmarking & code development)

ENSDF & XUNDL - cont.

A	NDS	Evaluator
109	NDS 137 (2016)	S. Kumar, J. Chen & F.G. Kondev
110	NDS 113 (2012)	G. Gurdal & F.G. Kondev
176	NDS 107 (2006)	M.S. Basunia
177	NDS 98 (2003)	F.G. Kondev
178	NDS 110 (2009)	E. Browne
179	NDS 110 (2009)	C.M. Baglin
199	NDS 108 (2007)	B. Singh
200	NDS 108 (2007)	F.G. Kondev & S. Lalkovski
201	NDS 108 (2007)	F.G. Kondev
202	NDS 109 (2008)	S. Zhu & F.G. Kondev
203	NDS 105 (2005)	F.G. Kondev
204	NDS 111 (2010)	C.J. Chiara & F.G. Kondev
205	NDS 101 (2004)	F.G. Kondev
206	NDS 109 (2008)	F.G. Kondev
207	NDS 112 (2011)	F.G. Kondev & S. Lalkovski
208	NDS 108 (2007)	M. Martin
209	NDS 126 (2015)	J. Chen & F.G. Kondev

aligned well with the ANL research effort

CARIBU @ANL



Atomic Data and Nuclear Data Tables 103-104 (2015) 50-105

Configurations and hindered decays of *K* isomers in deformed nuclei with *A* > 100

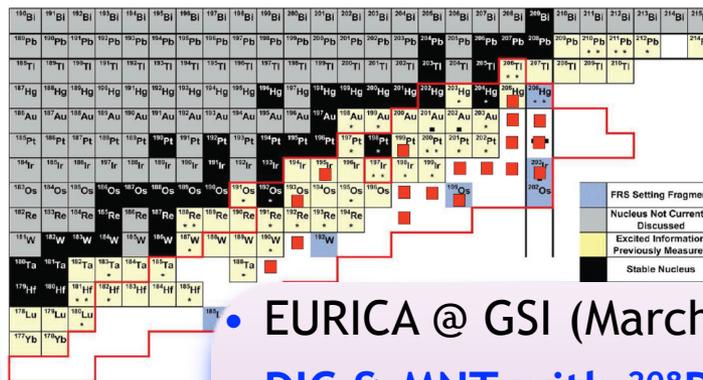
F.G. Kondev^{a,*}, G.D. Dracoulis^{b,1}, T. Kibédi^b

IOF Publishing

Reports on Progress in Physics

Review of metastable states in heavy nuclei

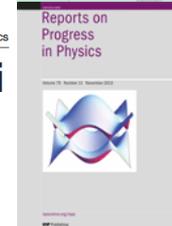
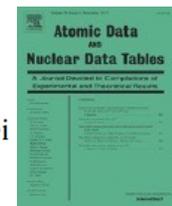
G D Dracoulis^{1,4}, P M Walker² and F G Kondev³



- EURICA @ GSI (March 2006)
- DIC & MNT with ²⁰⁸Pb beams or targets & Gammasphere
- new RIKEN project near N=126
- N=126 factory at ANL

17 mass chains; one to ORNL

XUNDL compilation proposal: compile data produced at CARIBU & ATLAS; voluntary check drafts of papers prior publications for ATLAS users



Nuclear Data Research Activities

relatively small effort (0.1 FTE) - complements and benefits the evaluation activities - sought after collaborator with little or no cost to USNDP

- ❑ at **ANL** - nuclei far from stability, spectroscopy of heavy and super-heavy nuclei, K-isomers, beta-decay spectroscopy & mass measurements in the FP region; *decay spectroscopy* of actinide nuclei and nuclei of importance to applications of medical isotopes and metrology
 - ✓ **CARIBU** - properties of neutron-rich nuclei (nuclear structure & masses, astrophysics & applications)
 - ✓ **FOA's** funded projects
 - ✓ **DTRA** interest in $^{131,133,135}\text{Xe}$ (and isomers) - harvesting at CARIBU (test); in collaboration with Strategic Security Sciences Division (ANL)
- ❑ at **MSU** (Coulex & decay spectroscopy), **TRIUMF** (decay spectroscopy) & **RIKEN** (decay spectroscopy) - properties of neutron-rich nuclei far from the line of stability

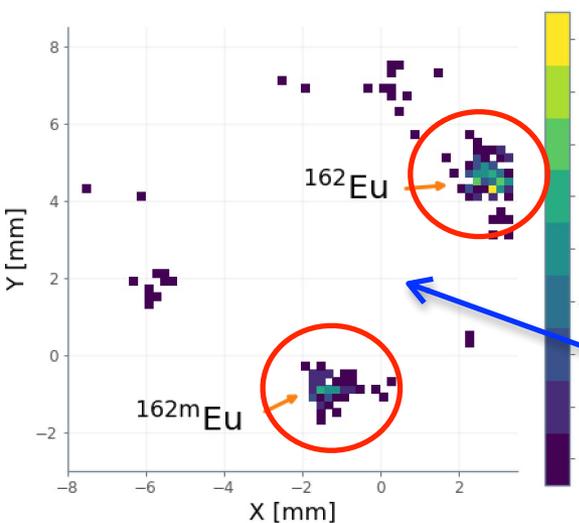
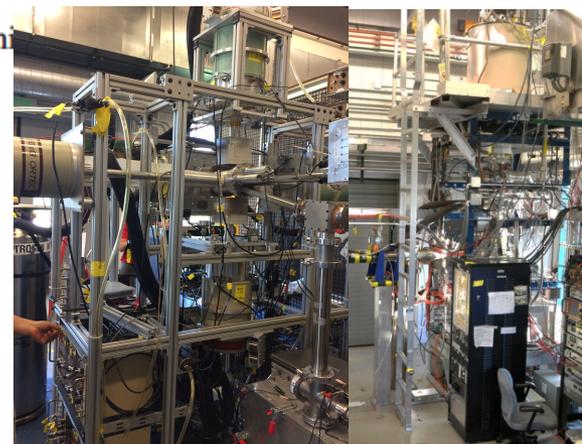
Decay studies in the light rare-earth region

PHYSICAL REVIEW LETTERS 120, 182502 (2018)

Masses and β -Decay Spectroscopy of Neutron-Rich Odd-Odd $^{160,162}\text{Eu}$ Nuclei: Evidence for a Subshell Gap with Large Deformation at $N=98$

D. J. Hartley,¹ F. G. Kondev,² R. Orford,^{2,3} J. A. Clark,^{2,4} G. Savard,^{2,5} A. D. Ayangeakaa,^{2,*}
S. Bottoni,^{2,†} F. Buchinger,³ M. T. Burkey,^{2,5} M. P. Carpenter,² P. Copp,^{2,6} D. A. Gorelov,^{2,4}
K. Hicks,¹ C. R. Hoffman,² C. Hu,⁷ R. V. F. Janssens,^{2,‡} J. W. Klimes,² T. Lauritsen,² J. Sethi,
D. Seweryniak,² K. S. Sharma,⁹ H. Zhang,⁷ S. Zhu,² and Y. Zhu⁷

CARIBU (high-purity beams of FP)
& X array (spectroscopy) & CPT (masses)

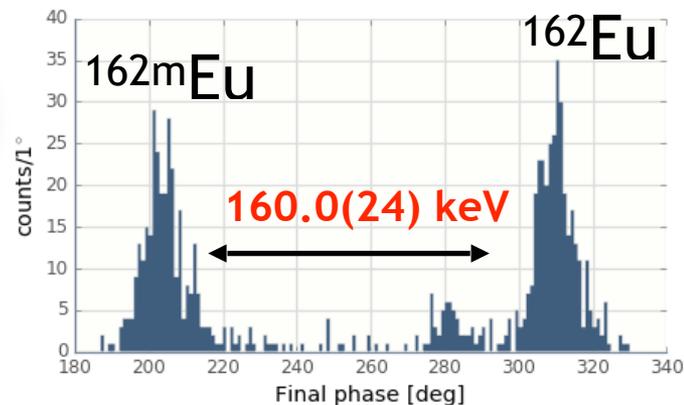


CPT mass measurements @ANL
 v_c relative to ^{84}Kr

$$ME(\text{gs}) = -58723.9 (15)$$

$$ME(\text{is}) = -58563.9 (19)$$

$$ME(\text{JYFL}) = -58658 (4)$$



phase-imaging ion-cyclotron-resonance (PI-ICR) technique

Contributions to FOA's funded projects

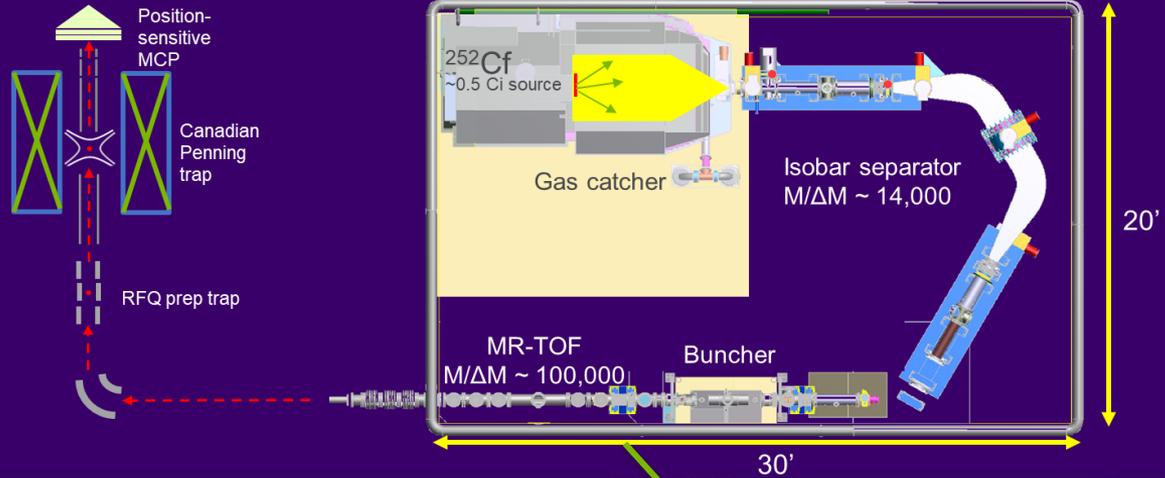
Objective

Significantly improve Nuclear Data in the Fission Product region - cross-cutting overlap with the main ND stakeholders DOE-SC/NP (Nuclear Structure & Astrophysics) & DOE-NNSA/NA-22 (applications)

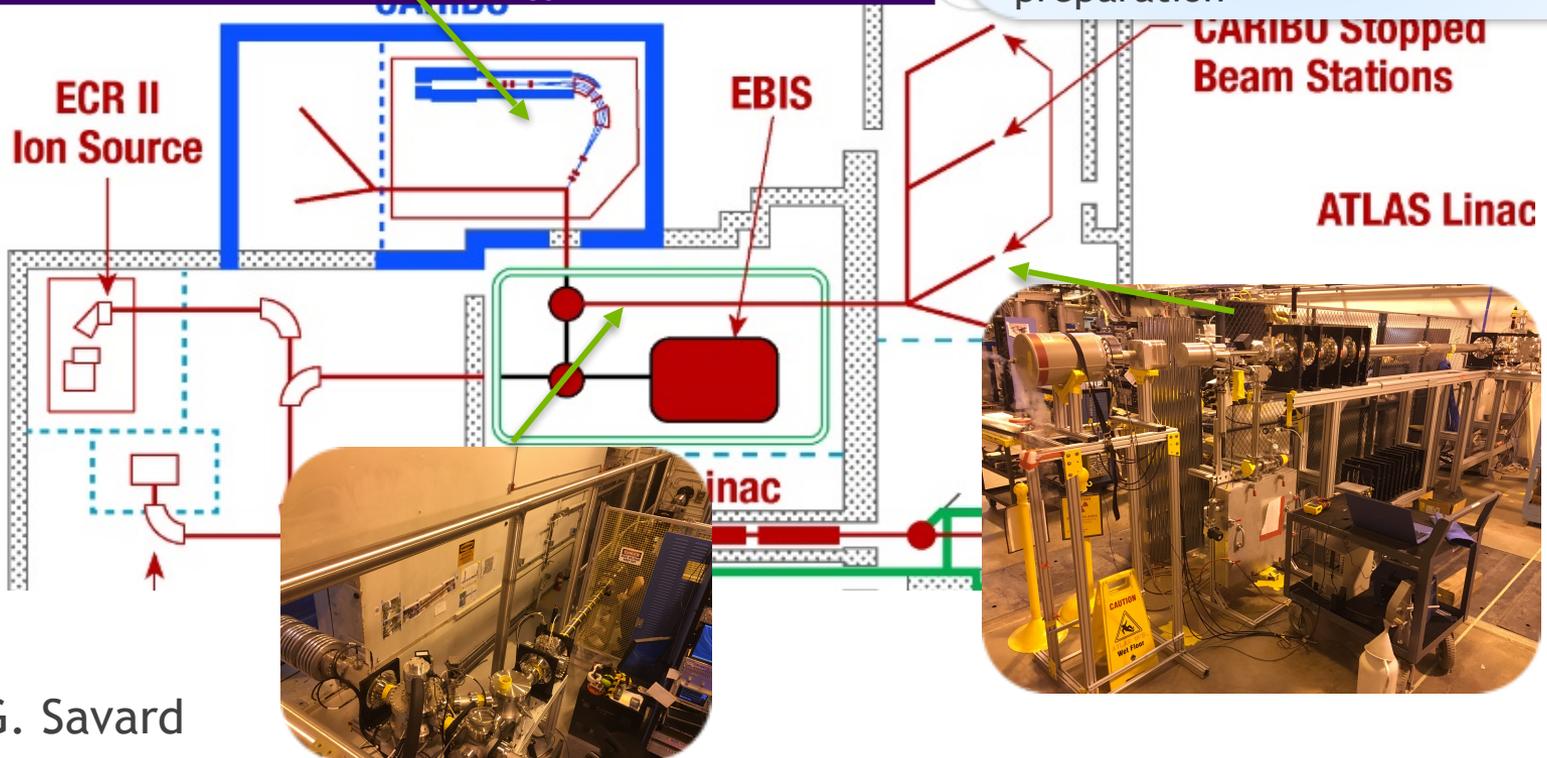
- ❑ Improving the Nuclear Data on Fission Product Decays at CARIBU (PI: G. Savard)
 - ✓ 5 years project
 - ✓ collaboration with LLNL - \$1M from DOE/SC/NP to ANL and \$1M from NNSA/NA-22 to LLNL

- ❑ Novel Approach for Improving Antineutrino Spectra Predictions for Nonproliferation Applications (PI: F.G. Kondev)
 - ✓ 3 years project - \$375K from DOE/SC/NP and \$375K from NNSA/NA-22
 - ✓ collaborations with LSU, WUSL & USNA & others via IAEA-NDS coordination

CARIBU WITH IMPROVED MASS SELECTION AND NEW LOWER BACKGROUND EXPERIMENTAL AREA NOW AVAILABLE



- neutron-rich isotopes from all fission products available as clean beams
- beam-line to the X-array in new low-background experimental area now completed
- high purity collection and absolute branching ratio on ^{95}Zr , ^{144}Ce and ^{147}Nd completed and analyzed - publication is in preparation



Courtesy: G. Savard

Contributions to FOA's funded projects



Why

- Most of the existing discrete spectroscopy data are taken with a single Ge detector leading to incomplete decay schemes for the fission products
- The calorimetry (TAGS) data is model dependent and have large systematic uncertainties (could be as high as 100%)

How

- Utilize high-purity FP beams from CARIBU - no stopovers for refractory elements
- Combine discrete γ -ray spectroscopy & calorimetry within a single device - **GAMMASHERE** - a step to the future **GRETA** spectrometer - the best calorimeter ever

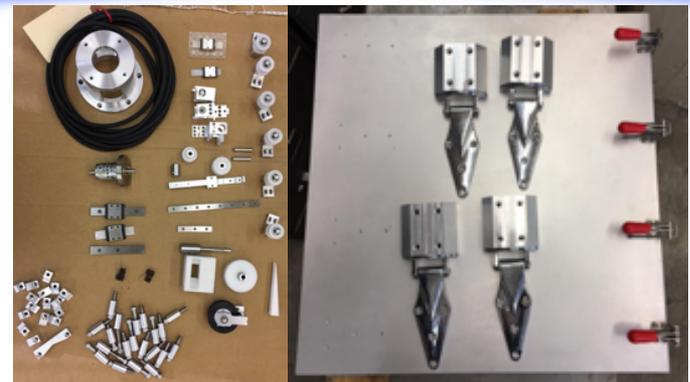
Status

FY2018

- designed and built needed infrastructure
 - ✓ new target chamber - WUSL
 - ✓ new tape station - LSU
 - ✓ beta-particle detector systems - ANL
- HEART (HEXagonal ARray for Triggering)
- commissioning - December 17-22, 2018
- post-doc (Dr. Pat Copp, UML graduate) - hired in August, 2018

FY2019

- Execute Nuclear Data measurements for nuclides that are on the IAEA priority list: two experimental campaign are envisioned
- Analyze the collected experimental data and publish the results in peer-reviewed journals - stay tuned!



Future (FY19 and beyond) Plans

- ❑ Continue contributing to XUNDL & ENSDF - top priority - closer connections with ATLAS & FRIB user communities
- ❑ Continue AME & NuBase collaboration activities
 - ✓ maintain the currency (5-6 yrs cycle) and quality
- ❑ Continue topical collaborations with IAEA-NDS, other USNDP groups & wide nuclear physics community
- ❑ Continue research activities with emphasis on nuclear structure physics and astrophysics, and their intersection with the applied nuclear physics
 - ✓ **ATLAS & CARIBU** - nuclear structure, masses & astrophysics, with emphasis on properties of neutron-rich nuclei in the deformed, light rare-earth region ($A \sim 160$) and the heavy region south of ^{208}Pb (**N=126 factory**); contributions to two FOA's projects in collaboration with LLNL, USNA, LSU, UND and others ...
 - ✓ **NSCL (FRIB), RIKEN & IMP (HIAF)** - nuclear structure, masses & astrophysics

Publications & Invited talks - FY18

- Publications in refereed journals: 13
- Invited talks: 9
- Reports: 4

- Convener of the Nuclear Data Working Group at the 2nd China-US “RIB Meeting on Nuclei and Hadrons”, October 16-18, 2017, Peking University, Beijing, China
- Consultants’ Meeting on “Total Absorption Gamma-ray Spectroscopy”, February 19-21, 2018, IAEA Headquarters, Vienna Austria

Personnel & Effort - FY18 & FY19

- 1 head, but 0.85 FTE SC/NP/ND funded staff
 - ✓ 0.15 FTE (FOA funding from NNSA/NA-22 & SC/NP)

Issue

- ANL-ND staff needs to look for other work in order to fill the gap
 - ✓ FOA17 funding helps, but will expire in FY2020 ...